ocean, and evapotranspiration occurs throughout the cycle. As water makes this journey, its chemistry changes. While in the air, water equilibrates with atmospheric gases. In shallow soils, it undergoes chemical exchanges with inorganic and organic matter and with soil gases. In ground water, where transit times are longer, there are more opportunities for minerals to dissolve. Similar chemical reactions continue along stream corridors. Everywhere, water interacts with everything it touches—air, rocks, bacteria, plants, and fish—and is affected by human disturbances.

Scientists have been able to define several interdependent cycles for many of the common dissolved constituents in water. Central among these cycles is the behavior of oxygen, carbon, and nutrients, such as nitrogen (N), phosphorus (P), sulfur (S), and smaller amounts of common trace elements.

Iron, for example, is an essential element in the metabolism of animals and plants. Iron in aquatic systems may be present in one of two oxidation states. Ferric iron (Fe^{3+}) is the more oxidized form and is very sparingly soluble in water. The reduced form, ferrous iron (Fe^{2+}), is more soluble by many orders of magnitude. In many aquatic systems, such as lakes for example, iron can cycle from the ferric state to the ferrous state and back again (**Figure 2.19**). The oxidation of ferrous iron followed by the precipitation of ferric iron results in iron coatings on the surfaces of some stream sediments. These coatings, along with organic coatings, play a substantial role in the aquatic chemistry of toxic trace elements and toxic organic chemicals. The chemistry of toxic organic chemicals and metals, along with the cycling and chemistry of oxygen, nitrogen, and phosphorus, will be covered later in this section.

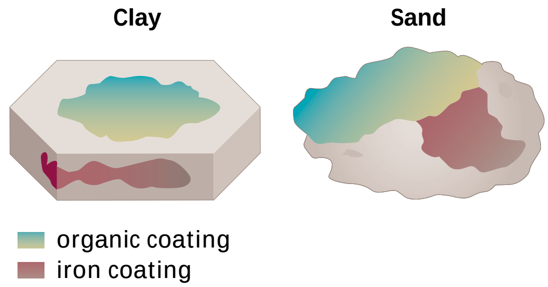

Figure 2.19: The organic and inorganic coatings on suspended sediment from streams. *Water chemistry determines whether sediment will carry adsorbed materials or if stream sediments will be coated.*

The total concentration of all dissolved ions in water, also known as salinity, varies widely. Precipitation typically contains only a few milligrams per liter (mg/L) of dissolved solids, while the salinity of seawater averages about 3,500 mg/L (**Table 2.5**). The concentration of dissolved solids in freshwater may vary from only 10 to 20 mg/L in a pristine mountain stream to several hundred mg/L in many rivers. Concentrations may exceed 1,000 mg/L in arid watersheds. A dissolved solids concentration of less than 500 mg/L is recommended for public drinking water, but this threshold is exceeded in many areas of the country. Some crops (notably fruit trees and beans) are sensitive to even modest salinity, while other crops, such as cotton, barley, and beets, tolerate high concentrations of dissolved solids. Agricultural return water from irrigation may increase salinity in streams, particularly in the west. Recommended salinity limits for livestock vary from 2,860 mg/L for poultry to 12,900 mg/L for adult sheep. Plants, fish, and other aquatic life also vary widely in their adaptation to different concentrations of dissolved solids. Most species have a maximum salinity tolerance, and few can live in very pure water of very low ionic concentration.